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AGRONOMICAL AND NUTRITIONAL RESPONSES OF SOME FABA BEAN (*Vicia faba* L.) GENOTYPES TO ORGANIC FERTILIZATION UNDER SANDY SOIL CONDITIONS

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ABSTRACT

Formulating applied vermicompost in combination with plant and animal compost as a plant nutrient could improve the performance of faba bean cultivars in reclaiming areas. In the present study, agronomical and nutritional quality traits of some faba bean genotypes were evaluated as a response to organic fertilization under sandy soil conditions. Two field trials were carried out under a drip irrigation system in the Desert Experimental Station, Faculty of Agriculture, Cairo University in Wadi El-Natroon, El-Beheira Governorate, Egypt, during two winter seasons, 2018/2019 and 2019 /2020. A split-plot design in randomized complete blocks arrangement, with four replications was used. Main plots were devoted to three cultivars, and sub-plots were allocated to nine treatments (plant compost, chicken manure, and vermicompost combinations). The results indicated that both cultivars and treatments of organic fertilizers showed highly significant mean squares effects for all studied traits. Besides, both years revealed a significant and positive correlation between seed yield per hectare (ha) and other studied traits. The response of faba bean cultivars to plant compost plus vermicompost activated the highest seed yield and its components as compared to all other treatments. In addition, the application of organic amendments achieved the highest values of seed chemical contents. The response of Sakha-1 cultivar to 100 % plant compost attained the highest response of yield, crude protein, ether extract, and amino acid contents. Remarkably, the interaction between Sakha-1 cultivar and 100 % plant compost plus vermicompost achieved the optimal combination, leading to the highest seed yield (3.12 ton/ha). This mixture is recommended to improve faba bean yield and the nutritional quality of seeds under sandy soil conditions.

Key words: ***Broad bean, Vicia faba, Multivariate analysis, Protein, Carbohydrates, Amino acid***.

INTRODUCTION

Faba bean or broad bean is considered one of the most popular legume foods worldwide due to its richness in seed protein contents and carbohydrates (Crepon *et al*., 2010). In Egypt, it has become a famous dish for human nutrition daily. Thus, the demand raising sharply than its consumption, whereas both harvested area and seed production of faba bean decreased rapidly from 77149 to 24420 (ha) and 233523 to 105051 (ton), respectively, about more than 80% self-insufficiency in the last decade as outlined by F.A.O (2022). Therefore, more efforts were carried on to achieve reducing that gap. (Darwish and Abdalla 1997) they reported some of these efforts as a guideline of strategies for improving faba bean varieties to alleviate instability of yield production across multi locations due to constrains caused by various biotic and abiotic stresses. Screening of faba bean genetic background and the importance of modern molecular genetics protocols assisted these programs as mentioned by Maalouf *et al*. (2019). Moreover, helpful opinions suggest expanding the faba bean planted area into marginal lands adequate for horizontal growing. Meanwhile, low soil fertility is a significant constraint for crop production in Saharan Egypt. Therefore, a suitable and balanced nutrient application is recommended to enhance crop productivity in this region, especially in soils with poor nutrient content. Caliskan *et al*. (2008) also suggested that maintaining soil fertility and using plant nutrients in sufficient and balanced amounts is critical in increasing crop yield in sub-Saharan countries. The growth habit of the faba bean plant is regarded as fixing atmospheric nitrogen, which in turn aids in increasing and maintaining soil fertility. Thus, it established well for the recovery of reclaimed lands, especially in semi-arid regions (Denton *et al*., 2017and Peoples *et al*., 2009). Hendawey and Younes (2013) reported that both Sakha-3 and Sakha-4 cultivars possessed a high yield components and seed quality parameters, plant height, fresh weight, seed yield/plant, 100-seed weight, seed yield, protein yield, and total vicine comparing with other Egyptian faba bean cultivars that studied in El-Sheikh Zuwayid region (North Sinai).

Productivity of the faba bean crop plant is affected by many factors, involving chemical and organic fertilizers. So, induced compounds such as minerals or biostimulant for plant growth not only increase yield productivity, but also accelerate more consumed time than its spending to release a promising cultivar during the breeding program. In addition, the benefits of bio-organic fertilizers such as: organic manure, biofertilizers, and biogas manure, as well as compost and its combinations, could resolved these issues and make our ecosystem healthier (Ritika and Utpal, 2014). Thus, it is important to develop credible and usable alternatives to overcome the limitation of chemical inputs. Many organic materials have been proposed as a source of nutrients for plant crops. Compost is considered a promising bio-stimulant source as mentioned by Mupambwa *et al*. (2015). Many recent studies stated that compost and other similar components could be used to improve and regulate plant growth and enhance stress tolerance (Nardi *et al*., 2002 and Siddiqui *et al*., 2008). Tammam *et al*. (2022) mentioned that the application of vermicompost to sandy soils is proper, as it helps exceed organic matter composition in soil. Likewise, it is vital in improving soil aeration, sustaining good soil aggregation, protecting against soil erosion, and increasing nutrient availability for stand plants. Moreover, vermicompost also contains various plant nutrients. Also, its components input amendment enhanced the nodulation and yield of faba bean in sandy clay loam soil under rainfed conditions (Argaw and Mnalku, 2017).

The plant compost caused an increase in seed yield than in organic animal applications when applied to three cultivars of faba beans in sandy soil conditions (Badawy *et al*., 2020). However, the productivity of faba bean is affected by a variety of abiotic stresses in sandy soils, such as saline water, salty soil, and a low level of nutrients. (Abbas *et al*., 2022). In this regard, we were formulating the application of vermicompost and plant and animal compost combinations with high plant nutrients to improve the performances of some newly released cultivars of Egyptian faba beans. For yield, its components, and the chemical compositions of seeds in reclaiming areas. Therefore, this study was carried out to elucidate the effect of vermicompost application and other combinations of organic fertilizers for enhancement of yield productivity and nutritional contents of faba bean.

MATERIALS AND METHODS

Experimental procedures

Two field trials in this investigation were carried out based on drip irrigation system in the Desert Experimental Station, Fac. of Agric., Cairo Univ. in Wadi El-Natroon, El-Beheira Governorate, Egypt, (located between 30º32'30" to 30º 33'0" N; and 29º 57'15" to 29º58'15" E, with 45 meters altitude) during two winter seasons 2018/2019 and 2019 /2020.

Experimental site soil was classified into sandy, saline, and poor in nutrients, and organic matter. Besides, irrigation water was saline according to its properties which are presented in Table (1).

Table 1. Properties of soil and irrigation water on the experimental site in 2018/19 and 2019/2020 seasons.

Soil analysis											2018/19	2019 /2020
Physical properties												
Sand %											94.65	92.00
Silt %											4.10	4.98
Clay %											1.15	3.02
Texture											Sandy	Sandy
Chemical properties												
Soil (pH)											7.88	7.54
Ec (ds/m)											5.33	5.39
Organic Matter (%)											0.35	0.38
Total $CaCO_3$ (%)											2.26	3.76
Available N (mg kg^{-1})											0.73	4.6
Available P (mg kg^{-1})											1.43	2.29
Available K (mg kg^{-1})											145	170
Chemical properties of irrigation water												
Season	pH	EC		Ions concentration meq/L								
		dS/m	PPM	HCo_3^-	Cl^-	$So_4^=$	Ca^{++}	Mg^{++}	Na^+	K^+		
2018/2019	7.7	4.4	2816	2.8	30.0	9.1	3.5	4.3	33.0	0.54		
2019/2020	7.6	4.5	2880	3.3	28.6	7.9	5.2	4.7	31.4	0.44		

Each field trial consisted of 27 plots, formed by the combinations of various levels of two studied factors. The first factor included three cultivars of Egyptian faba bean (Giza-843, Sakha-1, and Sakha-4) obtained from Food Legume Crops Section, Field Crops Research Institute, ARC, Giza.

These cultivars' features were generally identified as an early mature, promising established in northern regions and newly reclaimed lands. Besides, the second factor involved control and formed combinations of organic fertilizers. (T1: Control, T2: 50% Chicken manure, T3: 100% Chicken manure, T4:50% Plant compost, T5: 100% Plant compost, T6:50% Chicken manure with Vermicompost, T7:100% Chicken manure with Vermicompost, T8: 50% Plant compost with Vermicompost and T9:100%

Plant compost with Vermicompost). The properties of plant compost, chicken manure and vermicompost is presented in Tables (2 and 3), respectively.

Table 2. Organic amendments' physical and chemical characteristics.

Character	Plant compost	Chicken manure
Moisture content (%)	**25.00**	**22.00**
pH $_{(1:10)}$	**7.00**	**8.04**
EC $_{(1:10)}$ (dS m^{-1})	**2.65**	**3.20**
Total Nitrogen (%)	**2.15**	**2.24**
Organic Matter (%)	**1.671**	**1.885**
Organic Carbon (%)	**38.90**	**17.98**
Ash (%)	**32.8**	**69.00**
C: N Ratio	**18:1**	**8:1**
Total Phosphorus (P_2O_5) (%)	**1.09**	**0.16**
Total Potassium (%)	**2.55**	**0.59**
Weed seeds	**-----**	**-----**
Nematodes	**-----**	**-----**

Table 3. Vermicompost's physical and chemical characteristics.

Physical properties	
Bulk density kg/m^3	**1070**
Moisture content%	**20**
Chemical properties	
pH	**8.5**
EC (dS/m^{-1})	**0.85**
Organic matter%	**50.9**
Organic carbon%	**29.5**
Ash%	**42**
Total nitrogen%	**1.9**
C: N ratio	**14:1**
Total phosphorus%	**0.95**
Total potassium%	**1.21**

Split-plot design was used for this experiment in a randomized complete blocks arrangement, with four replications. Main plots were devoted to three cultivars, and sub-plots were allocated to nine treatments (plant compost, chicken manure and vermicompost combinations). Each subplot consisted of three rows of 3 m in length and 0.50 m in width with an area of 4.5 m^2. Plant density was twenty-six plants/m^2 were obtained by seeding two seeds in hills spaced 30 cm apart on both sides of the ridge (50 cm width).

The two organic amendments were incorporated at a rate of 12 tons ha^{-1} before sowing. Vermicompost was added in solid form to the soil beside plants in equal intervals at 45, 60, and 75 days after sowing. All farming practices were conducted in accordance with recommendations of ARC, Ministry of Agriculture, concerning faba bean production.

Studied characters

At harvest, ten guarded plants were taken randomly from each experimental plot to estimate the following traits: plant height (cm), number of branches, number of pods $plant^{-1}$, number of seeds $plant^{-1}$, weight of seeds $plant^{-1}$, and seed index, harvest index, biological yield. In addition, seed yield (ton ha^{-1}) was weighed from the whole area of each subplot and adjusted to yield per hectare. Harvest index (%) was calculated as follow: Seed yield / Biological yield × 100.

Chemical characteristics of seeds

The protein content was determined by the Kjeldahl method, ashing was carried out in a muffle, and oxidizing atmosphere at a temperature of 900 ± 10 °C, and crude fiber and ether extract were determined by the Soxhlet method. Grains were measured by using the appropriate protocols according to the Association of Official Agricultural Chemists, A.O.A.C. (2000). The Carbohydrate content of grains was calculated as follows: carbohydrates (on a dry basis) = 100 − (ash + ether extract + protein + fiber). Amino acid compositions were determined according to the method described in A.A.C.C. (2000).

Statistical analyses

Serials of statistical analyses were conducted for collecting data that had been begun by normality test according to Shapiro-Wilk (1965), subsequently finding the significance of meaning squares for the assumption of regular RCBD from each season (Snedecor and Cochran,1989). However, combined analysis across seasons was presented in this investigation that was conducted as indicated by normality and homogeneity tests. The homogeneity test based on homogeneity error variances of both seasons for each trait which was performed according to Hartley's F_{max}test (1950). Furthermore, the estimation of differences between means depended on the level of significance (p 0.05) using Duncan's multiple-range tests (Duncan 1955), by using different superscript letter as a significant difference between the treatments. In addition, the correlation coefficients were calculated to explain the interrelationships of all possible pairs of studied traits. Otherwise, multivariate analysis such as cluster analysis which was presented as a graphical method through dendrograms to utilize squared Euclidian distance between groups' averages of effects varied nine treatments and outcomes of impressive cluster scheme is an essential factor for correct interpretation of that kind of treatments similarity for each cultivar. All data were processed by MSTAT- Cv.2.10 and SPSS v.27software package program modified by extensions hub with R program.

RESULTS AND DISCUSSION

Significances of studied factors and averages of yield and yield components

The obtained data of studied traits were diagnosed as normal distribution by normality tests according to the Shapiro-Wilk test at $p > 0.05$. Subsequently, a combined analysis of variance across the two seasons was performed after testing homogeneity of its error variances. Significance due to various sources of variation for combined analysis is presented in Table (4) based on the combined analysis. Mean squares of seasons (S) were non-significant for all studied traits except numbers of seeds/plant, biological yield per plant, and seed yield ton per hectare. The presented results are consistent with the perception of faba bean as an unpredictable and variable crop in adequate temperate climates (Bond *et al*., 1985) and for seed yield by Loss and Siddique (1997). This finding proved that traits are affected by different seasons and environmental impacts.

Table 4. Significance of mean squares due to sources of variation for combined analysis of studied traits across the two seasons.

SOV / Studied traits	Season	Cultivars	Season × Cultivars	Treatments	Season × Treatments	Cultivars × Treatments	Season × Cultivars × Treatments
Plant height cm	ns	**	ns	**	ns	**	ns
No. Branches/plant	ns	**	ns	**	**	ns	ns
No. pods/Plant	ns	**	ns	**	ns	**	ns
No. seeds/Plant	*	**	**	**	**	**	ns
Seed yield/plant (g)	ns	**	**	**	ns	**	ns
Harvest index%	ns	**	ns	**	**	**	ns
Seed index (g)	ns	**	**	**	**	*	ns
Seed yield ton/ha	**	**	ns	**	ns	ns	*

ns, * and ** indicated non–significant, significant at 5% and highly significant at 1 % level of probability, respectively.

Similar to the interactions among different levels of factors of two seasons which were obtained in the interaction among seasons, cultivars and treatments were non-significant for all studied characteristics except the percentage of harvest index (%) and seed yield ton ha^{-1}.

However, both two-factor cultivars and treatments of organic fertilizers showed highly significant mean squares for all studied characteristics. Their mean effects were determined and explained in Figure (1) respectively. The mean performances of the three studied cultivars were presented in a bar chart across the two seasons across all the nine treatments, whereas Sakha-1 possessed the highest recorded value of all studied characteristics except the number of seeds/plant. On the other hand, Giza-843 exceeded in this trait, but it was exhibited among studied cultivars for the other traits. Neither Giza-843 nor Sakha-4 showed significant differences in the numbers of branches/plant.

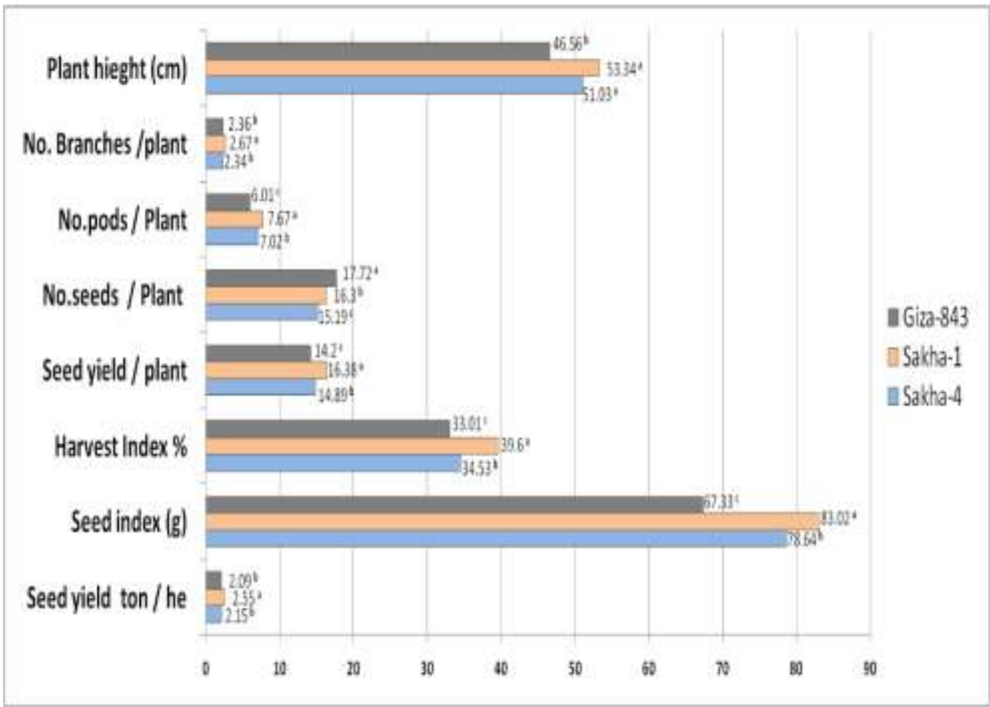

Fig.1. Bar chart illustrated the combined analysis of cultivars mean performance for each studied character across seasons and treatments. Similar letters don't differ significantly at 0.05 level of significant.

Generally, all parameters of growth and yield have a significant increase by using 100% plant compost plus vermicompost, except the harvest index. Remarkably, the results in Table (5). indicated that faba bean plants were treated with 100% plant compost plus vermicompost attained the highest plant height values (64.65 cm), number of branches /plant (3.18), number of pods/plant (8.69), number of seeds/plant (21.84), yield/plant (21.80 g), seed yield (2.77 ton/ha) and seed index (91.82g). However, the highest value of harvest index, was achieved under the treatment of 100% chicken manure (39.31 %).

Table 5. Mean effects of studied compost and vermicompost combinations compared with control cross the two seasons for each studied character.

Treatments / Studied traits	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9
Plant height cm	39.98 ^{g}	42.52^{fg}	48.49^{d}	44.42^{ef}	58.46^{b}	46.97^{de}	55.07^{c}	52.23^{c}	64.65 ^{a}
No. Branches/plant	2.05^{d}	2.23^{cd}	2.38^{bc}	2.40^{bc}	2.33^{bcd}	2.34^{bcd}	2.62^{b}	2.56^{b}	3.18^{a}
No. pods/plant	4.59 ^{g}	5.73^{f}	7.01^{d}	6.33^{e}	8.11^{b}	6.75^{d}	7.55^{c}	7.33^{c}	8.69^{a}
No. seeds/plant	9.83^{h}	13.16^{g}	16.13^{d}	14.2^{f}	19.53^{b}	15.11^{e}	19.23^{b}	18.59^{c}	21.84^{a}
Seed yield/plant(g)	8.34^{h}	10.18^{g}	15.15^{d}	12.43^{f}	18.89^{b}	13.4^{e}	18.59^{b}	17.62^{c}	21.8^{a}
Harvest Index%	36.68^{abc}	37.44^{ab}	39.31^{a}	34.35^{bc}	37.44^{ab}	34.6^{bc}	34.3^{bc}	33.08^{c}	34.24^{bc}
Seed index (g)	64.72^{e}	65.07^{e}	74.67^{d}	71.13^{d}	85.71^{b}	71.92^{d}	82.52^{bc}	79.38^{c}	91.82^{a}
Seed yield ton/ha	1.72^{h}	1.99^{g}	2.26 ^{de}	2.09^{f}	2.55^{b}	2.18^{e}	2.44 ^{c}	2.35^{cd}	2.77^{a}

Means of rows (different effect of compost treatments of each studied trait) where T_1: Control, T_2: 50% Chicken manure, T_3: 100% Chicken manure, T_4:50% Plant compost, T_5: 100% Plant compost, T_6:50% Chicken manure with Vermicompost, T_7:100% Chicken manure with Vermicompost, T_8: 50% Plant compost with Vermicompost and T_9:100% Plant compost with Vermicompost; followed by the same letters are not significantly different at 0.05 level of significant.

A significant difference was observed between cultivars and plant compost, chicken manure with vermicompost in all parameters of growth and yield (Table 6). Sakha-1 cultivar response to plant compost plus vermicompost was reflected in the highest responding of plant height (71.30 cm), number of branches /plant (3.36), number of pods/plant (9.90), number of seeds/plant (22.53), yield/plant (23.82 g), seed index (98.45g) and seed yield (3.12 ton/ha). However, as regards the harvest index, the great value (48.98 %) was recorded with the interaction between cultivar Sakha-1 under 100% of chicken manure.

The positive effect of organic fertilizer could result from the organic fertilizer content of various sources on the organic compounds. i.e., sugars, amino acids, humic acids, and organic acids, all these compounds contribute directly or indirectly to the growth and development of the plant or they affect the nutrient availability already present in the soil by improving soil pH and thus improving plant productivity (Al-Bayati and Kammel, 2014). The application of compost (organic fertilization) determines the macro- and micronutrient release that improve the soil properties with a consequent increase of faba bean yield (Cucci *et al*., 2019). Further, Abou El-Hassan *et al*. (2017) indicated the possibility of using compost and vermicompost to reduce the mineral fertilizers to produce high yield of green beans. However, plant height increase was already observed on other legume species treated by vermicompost (Sinha *et al*., 2010). A superior increase in seed yield/fed was scored by plants sprayed with vermicompost tea (Gomaa and Afifi 2021).

These findings are in harmony with those obtained by Chaichi *et al.* (2018) who indicated that vermicompost tea is a helpful fertilizer to enhance faba bean growth. Eshetu *et al.* (2022) recommended that vermicompost with inorganic fertilizers may be used by integrated ways for crop production. Badawy *et al*. (2020) showed that plant compost caused an increase in seed yield compared to the use of chicken manure when applied to three cultivars of faba bean. In this context, Abbas *et al*. (2022) indicated that plant compost significantly increased faba bean yield compared with chicken manure under conditions of sandy soil. Moreover, Elnesairi and Elssalem (2020) showed that faba bean growth had been improved by using organic and inorganic fertilizations. Applying organic manures at rates of 4.8-7.1 ton/ha enhance growth of faba bean (Mahmoud *et al*., 2004). Plant compost with Sakha-1 cultivar seems as a good combination to enhance the faba bean productivity in natural salinity conditions (Badawy *et al*., 2020). Also, Abbas *et al*. (2022) concluded that Sakha-1 cultivar revealed the best performance when use plant compost in sandy soil compared to chicken manure.

Table 6. Interaction among control, different compost and vermicompost combination treatments (T1:T9) under effects of mean performance of three faba bean cultivars for each studied trait.

Cultivars	Treatments	Plant height cm	No. Branches/ plant	No. pods/Plant	No. seeds/Plant	Seed yield/plant (g)	Harvest index%	Seed index (g)	Seed yield ton/ha
Giza-843	T_1	38.78^{m}	2.10 ^{fg}	4.23^{n}	11.04^{m}	7.87^{s}	27.79^{j}	57.24^{m}	1.45^{p}
	T_2	41.3^{lm}	2.14^{efg}	4.95^{m}	14.21^{kl}	10.05^{pq}	33.12$^{e\sim j}$	59.85^{lm}	1.82^{no}
	T_3	44.22^{jkl}	2.20^{efg}	6.31^{k}	16.3^{gh}	14.64^{k}	35.19$^{d\sim i}$	65.57^{jkl}	2.16^{ijk}
	T_4	42.95^{klm}	2.29$^{d\sim g}$	5.11^{m}	15.16^{j}	11.55^{no}	29.14$^{e\sim j}$	62.83^{klm}	1.92^{mn}
	T_5	50.13$^{e\sim h}$	2.26$^{d\sim g}$	6.99^{hij}	21.43^{c}	17.49^{gh}	37.24$^{g\sim j}$	75.86$^{f\sim i}$	2.32^{fgh}
	T_6	44.79$^{i\sim l}$	2.15^{efg}	5.78^{l}	15.54^{hij}	12.13^{mno}	34.43$^{d\sim i}$	63.38^{klm}	2.10 ^{jkl}
	T_7	49.99$^{e\sim i}$	2.60$^{b\sim f}$	6.79^{ijk}	21.86^{bc}	17.9^{efgh}	33.38$^{e\sim j}$	72.03$^{g\sim j}$	2.28^{ghi}
	T_8	49.22$^{f\sim j}$	2.39$^{c\sim g}$	6.61^{jk}	20.60 ^{d}	17.04^{hi}	32.62$^{g\sim j}$	69.5^{ijk}	2.21^{hij}
	T_9	57.67^{cd}	3.08^{ab}	7.36^{fgh}	23.3^{a}	19.14^{de}	34.2$^{d\sim i}$	79.72^{def}	2.53^{cde}
Sakha-1	T_1	42.43^{lm}	2.14^{efg}	5.19^{m}	8.76^{o}	9.11^{qr}	43.24^{abc}	77.05$^{e\sim h}$	2.01^{klm}
	T_2	43.73^{klm}	2.38$^{c\sim g}$	6.51^{jk}	11.83^{m}	11.24^{op}	45.38^{ab}	74.4$^{f\sim i}$	2.28^{ghi}
	T_3	50.74$^{e\sim h}$	2.63$^{b\sim e}$	7.55^{efg}	16.71^{fg}	15.99^{ij}	48.98^{a}	79.44^{def}	2.53^{cde}
	T_4	44.28^{jkl}	2.78^{bcd}	7.30 $^{f\sim i}$	13.48^{l}	13.23^{lm}	40.03^{bcd}	79.07$^{d\sim g}$	2.37$^{e\sim h}$
	T_5	64.68^{b}	2.51$^{c\sim f}$	8.96^{b}	19.93^{de}	20.86^{c}	39.51$^{b\sim e}$	89.85^{bc}	2.87^{b}
	T_6	47.86$^{g\sim k}$	2.46$^{c\sim f}$	7.44$^{e\sim h}$	14.79^{jk}	14.21^{kl}	38.04$^{c\sim g}$	77.22$^{e\sim h}$	2.43^{efg}
	T_7	60.51^{bc}	2.86^{abc}	8.24^{d}	19.45^{e}	20.06^{cd}	34.67$^{d\sim i}$	88.19^{bc}	2.67^{c}
	T_8	54.50^{def}	2.88^{abc}	7.90 ^{de}	19.21^{e}	18.9^{def}	33.71$^{d\sim i}$	83.47^{cde}	2.63^{cd}
	T_9	71.30^{a}	3.36^{a}	9.90 ^{a}	22.53^{ab}	23.82^{a}	32.82$^{f\sim j}$	98.45^{a}	3.12^{a}
Sakha-4	T_1	38.74^{m}	1.90 ^{g}	4.36^{n}	9.68^{n}	8.05^{rs}	39.02$^{b\sim f}$	59.88^{lm}	1.71^{o}
	T_2	42.53^{lm}	2.16^{efg}	5.73^{l}	13.45^{l}	9.25^{qr}	33.83$^{d\sim j}$	60.95^{lm}	1.88^{mn}
	T_3	50.52$^{e\sim h}$	2.33$^{d\sim g}$	7.16$^{f\sim i}$	15.36^{ij}	14.81^{jk}	33.76$^{d\sim j}$	79.00 $^{d\sim g}$	2.1^{jkl}
	T_4	46.03$^{h\sim l}$	2.13^{efg}	6.59^{jk}	13.96^{l}	12.51^{mn}	33.89$^{d\sim j}$	71.51^{hij}	1.96^{lmn}
	T_5	60.57^{bc}	2.20 ^{efg}	8.39^{cd}	17.24^{f}	18.31^{efg}	35.56$^{d\sim h}$	91.42^{ab}	2.47^{def}
	T_6	48.24$^{g\sim k}$	2.41$^{c\sim g}$	7.03$^{g\sim j}$	15.00 ^{jk}	13.86^{kl}	31.32^{hij}	75.16$^{f\sim i}$	2.02^{klm}
	T_7	54.70^{de}	2.39$^{c\sim g}$	7.63^{ef}	16.36^{g}	17.8^{fgh}	34.84$^{d\sim i}$	87.34^{bc}	2.35^{fgh}
	T_8	52.96$^{d\sim g}$	2.41$^{c\sim g}$	7.48$^{e\sim h}$	15.96^{ghi}	16.93^{hi}	32.9$^{f\sim j}$	85.17^{bcd}	2.22^{hij}
	T_9	64.99^{b}	3.09^{ab}	8.81^{bc}	19.70 ^{e}	22.45^{b}	35.70 $^{d\sim h}$	97.31^{a}	2.67^{c}

Means of columns (different effects of interaction among cultivars and various compost treatments of each study trait) followed by the same letters are not significantly different at 0.05 level of significant.

Association of some studied traits with seed yield in faba bean three cultivars.

To determine the significance briefly for relationships among averages of nine studied traits across the two seasons, Person correlation coefficient with the colorful correlation matrix (Fig. 2) was conducted. Obtained data showed that harvest index revealed as a weak relation with all studied traits. Furthermore, relationships were informed to be negative for studied traits except for number of pods per plant, seed index, and seed yield ton. Besides, correlation coefficient was recorded around zero values for seed yield/plant, plant height, and the number of branches/plant with recorded -0.04, -0.03, and 0.02, respectively.

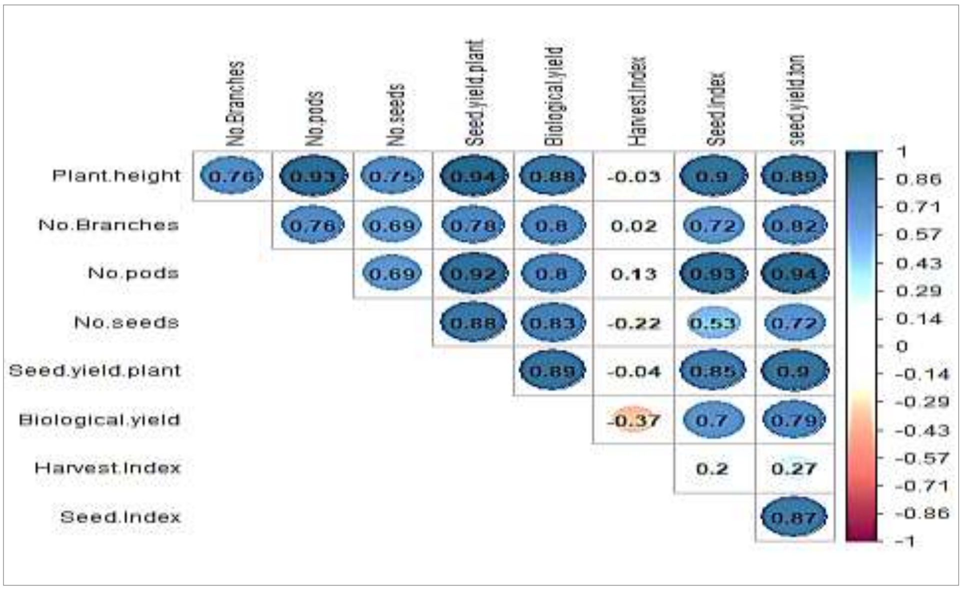

Fig. 2. Colorful correlation matrix elucidates the relationships among studied traits across 2 seasons (Blue, Red indicated positive negative relationships; respectively). Pair-wise relation is remarkable that fill colored cell significant at 5 % level of significance (p <0.05), Blank cell value non-significant (ns) relationship.

On the other hand, significant and positive correlations were exhibited between seed yield per ton and other traits in both years, especially the number of pods recorded r= 0.94. It was considered the highest significance character, presented with dark blue color, rendering the number of pods a valuable criterion for indirect selection for seed yield per plant. A significant positive correlation between seed yield and the number of pods confirmed the results obtained by Kambal (1969) and Berhe *et al*. (1998). The non-significant correlation between the seeds number and seed index obtained in this study (r=0.53), is in agreement with the results reported by Sindhu *et al*. (1985) and Yücel (2004). The non-significant correlation between seed yield and yield components of harvest index and biological yield was due to the ability of yield components to compensate for each other, and therefore, an improvement in one of them will lead to a decrease in the other components.

Multivariate analysis (cluster analysis) as an effective tool for interpretation of trends compost and vermicompost treatments on yield and its components:

Cluster analyses are one of the appropriate tools for grouping the tested different genotype's performances or other treatments of faba bean, according to mean effects for several traits into intra-similarity and inter-distinct groups (Afzal, *et al*., 2022). Due to detecting the similarity of organic fertilizing treatments affected, dendrograms (Fig 3) distinguished among various treatments at 5 % significance level for each cultivar. Giza 843 is classified into 4 primaries branched with two similar original nodes, created for groups A and B and two individual ungrouped Un-1 and Un-2. Obviously, cluster A included three treatments (T_5, T_7, and T_8), and group B involved four (T_2, T_3, T_4, and T_6), except treatment (T_9) which was defined as 100% plant compost with vermicompost, and it was classified a unique group (Un-1). In addition, control (T_1) was created as an ungrouped, tagged ungrouped 2 (Un-2). The dendrogram presented for Sakha-1 was also classified into two groups and ungrouped. Whereas, group (A) consisted of 5 treatments (T_1, T_2, T_3, T_4 and T_6) and group B included three treatments (T_6, T_7 and T_8).

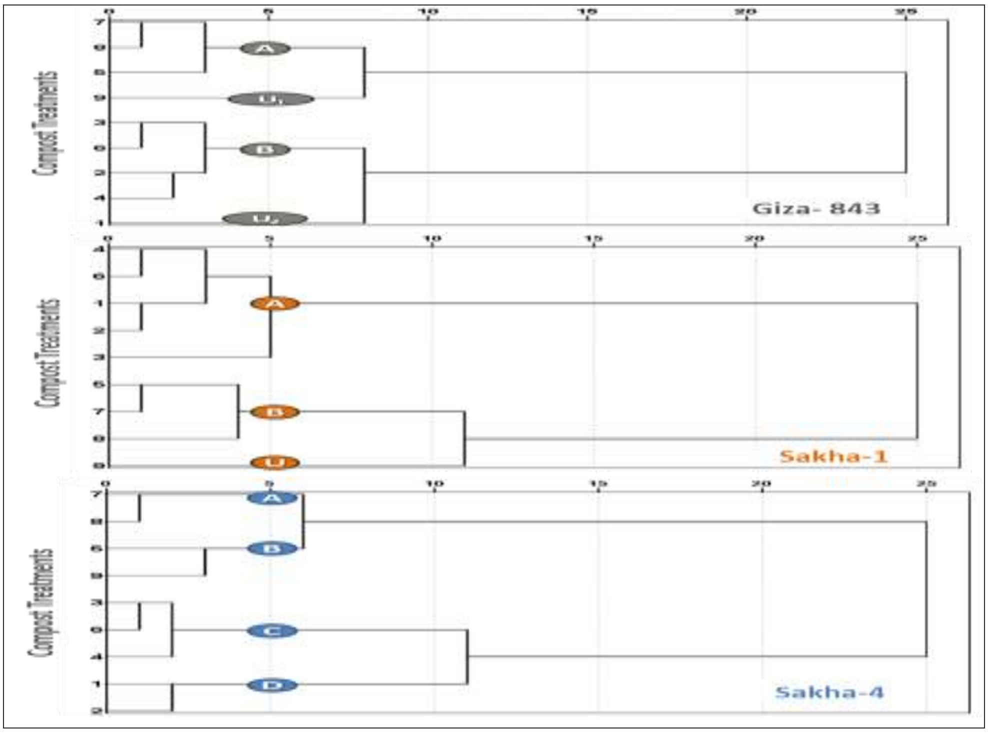

Fig. 3. Dendrograms using average linkage between groups according to different nine compost and vermicompost treatments involved all studied traits for each faba bean cultivar, dendrograms clustering calculated across the two seasons

However, one ungroups which defined for treatment 9 (T9), it seemed to be summarized that trend for groups of treatments for both Giza-843 and Sakha-1had been drawn similar, whereas the treatments of group B for Giza- 843 cultivar identical of treatments for group A of Sakha-1, vise versa. Beyond, that treatment 100% plant compost with vermicompost (T_9) was still created an ungroup. However, Sakha-4 its hieratical distribution was the most distinguished other than two cultivars, which formed 4 groups; the first group (A) involved two treatments ($T_7$and T_8). Also, the second group (B) was included two treatments T_5 and T_9. But the 3 rd group (C) involved three treatments T_3, T4, and T6, and the last group (D) it was formed by the rest 2 treatments (T_1 and T_2).

In addition to, describe of the detailed attributes and effects of treatments as summarized in Table (7) according grand mean of treatments in each group for each cultivar. Dendrogam of Giza- 843 presented 2 groups and another 2 ungroup, ungroup recorded averages as possessing lowest or highest values, i.e., ungroup which was involved T9 is considered the superior treatment was contrasting other treatments of all yield components except harvest index. However, control T1 indicated inferior treatment effects for all studied traits, Group A was better than group B, but it may be considered moderates effects, Sakha-1 treatments classification showed that behaved only one ungroup, which also consisted of T_9. The unique ungroup (Un1), including treatment T_9 was associated with highly performed for increasing yield components of both two cultivars, Giza-843 and Sakha-1.

Table 7. Mean performance of formed groups of compost and vermicompost treatments according cluster analysis of studied traits for each cultivar.

Cultivars	Groups	Plant height cm	No. Branches/ plant	No. pods/Plant	No. seeds/Plant	Seed yield/plant (g)	Biological yield/plant (g)	Harvest index%	Seed index (g)	Seed yield ton/ha
Giza-843	A	49.78	2.42	6.80	21.30	17.48	6.69	34.41	72.46	2.27
	Un1 (T_9)	57.67	3.08	7.36	23.3	19.14	7.42	34.2	79.72	2.53
	B	43.32	2.20	5.54	15.30	12.09	6.20	32.97	62.91	2.00
	Un2 (T_1)	38.78	2.1	4.23	11.04	7.87	5.55	27.79	57.24	1.45
Sakha-1	A	45.81	2.48	6.80	13.11	12.76	5.58	43.13	77.44	2.32
	B	59.90	2.75	8.37	19.53	19.94	7.73	35.96	87.17	2.72
	Un (T_9)	71.3	3.36	9.9	22.53	23.82	9.53	32.82	98.45	3.12
Sakha-4	A	52.96	2.41	7.48	15.96	16.93	6.77	32.9	85.17	2.22
	B	62.78	2.65	8.60	18.47	20.38	7.36	35.63	94.37	2.57
	C	48.26	2.29	6.93	14.77	13.73	6.16	32.99	75.22	2.03
	D	40.64	2.03	5.05	11.57	8.65	4.99	36.43	60.42	1.80

However, group B, according to Sakha- 4 consisted of T5 and T9, which ranked in the first position for increasing all yield components characters, mainly recorded 20.38 g, 35.36%, and 93.37 g of seed yield per plant, harvest index, and seed index respectively. Two treatments control T1, and T2 of group D decreased the efficiency of the effect on yield components. Meanwhile, those appeared as effects equivalence of almost of studied traits. This reduction of plant yield production showed for decreasing seed yield per plant about folds than group A from 16.93 g to 8.65 g from group A to group D, respectively. Therefore, we could conclude that treatment 9 is the best influence on yield and yield components of faba bean or all studied cultivars, and T 7 and T 8 ranked as second position while control is lowest effects , On the other mean, all treatment increasing the faba bean performances in sandy soil Generally, the heretical approach in the seemed applicable where that other groups in spite they included different treatments and it was distinguished for sets according to the metrological data across two seasons and suitable applied strategies of fertilizing treatments which adopted for controlling fertilizing in reclaimed lands.

Nutritional composition of seeds

Significant differences among organic fertilizers and cultivars in chemical composition of seeds were observed (Table 8). Sakha-1 cultivar had a higher crude protein content (25.23 g/100g). Giza-843 achieved higher ash, ether extract and contents of carbohydrates (4.29, 1.92 and 65.95 g/100g, respectively). While, Sakha-4 cultivar had a higher crude fiber content (4.87 g/100g). The results of Table (8) also showed that the organic amendments application achieved the great values seed chemical content of expect carbohydrate. The results of the current study showed that the cultivars of faba bean (Sakha-1, Sakha-4, and Giza-834) expressed significantly variation in response to organic amendments (plant compost, chicken manure with vermicompost as well as their combinations. Sakha-1 cultivar response to plant compost achieved the highest crude protein and ether extract value (27.74 and 2.09 g/100g, respectively).

Table 8. Seed chemical contents (g/100 g) as affected by cultivars and organic fertilization.

Cultivars	Treatments	Ash	Crude protein	Ether extract	Crude fiber	Carbohydrate
Giza-843		4.29	23.43	1.92	4.40	65.95
Sakha-1		3.98	25.23	1.85	4.83	64.12
Sakha-4		4.10	23.63	1.63	4.87	65.76
L.S.D $_{(0.05)}$		0.02	0.35	0.02	0.08	0.35
	T_1	3.16	21.61	1.28	0.89	73.06
	T_2	4.26	25.40	1.88	5.61	62.84
	T_3	4.04	25.19	1.86	5.12	63.79
	T_4	4.27	24.47	1.82	4.91	64.54
	T_5	4.30	25.17	1.94	5.17	63.42
	T_6	4.37	24.17	1.94	5.45	64.08
	T_7	4.44	23.67	1.87	5.01	65.01
	T_8	4.09	23.61	1.78	4.80	65.72
	T_9	4.19	23.61	1.82	5.34	65.03
L.S.D $_{(0.05)}$		0.03	0.61	0.04	0.14	0.61
Giza-843	T_1	3.07	20.03	1.30	0.86	74.75
	T_2	4.59	24.54	1.98	5.53	63.37
	T_3	4.30	25.19	2.07	5.28	63.17
	T_4	4.38	22.46	2.00	4.29	66.88
	T_5	4.43	24.97	2.01	5.05	63.55
	T_6	4.69	24.17	1.96	4.93	64.26
	T_7	4.62	24.10	2.04	5.04	64.20
	T_8	4.16	21.86	1.93	3.62	68.43
	T_9	4.42	23.59	2.01	5.02	64.97
Sakha-1	T_1	3.15	23.07	1.19	0.92	71.68
	T_2	4.01	27.74	2.09	6.08	60.09
	T_3	3.70	25.61	1.94	5.76	62.99
	T_4	4.14	24.81	1.92	5.01	64.13
	T_5	4.16	26.18	1.93	4.87	62.88
	T_6	4.13	24.57	1.94	4.75	64.61
	T_7	4.36	24.29	1.87	5.02	64.46
	T_8	4.08	25.55	1.88	5.07	63.43
	T_9	4.07	25.26	1.88	5.97	62.83
Sakha-4	T_1	3.27	21.72	1.36	0.89	72.76
	T_2	4.19	23.92	1.57	5.23	65.08
	T_3	4.11	24.78	1.57	4.33	65.21
	T_4	4.29	26.15	1.54	5.42	62.61
	T_5	4.31	24.36	1.89	5.61	63.84
	T_6	4.29	23.75	1.92	6.67	63.37
	T_7	4.35	22.61	1.71	4.98	66.35
	T_8	4.04	23.41	1.55	5.71	65.30
	T_9	4.10	21.99	1.58	5.04	67.30
L.S.D $_{(0.05)}$		0.05	1.05	0.07	0.25	1.05

Where T_1: Control, T_2: 50% Chicken manure, T_3: 100% Chicken manure, T_4:50% Plant compost, T_5: 100% Plant compost, T_6:50% Chicken manure with Vermicompost, T_7:100% Chicken manure with Vermicompost, T_8: 50% Plant compost with Vermicompost and T_9:100% Plant compost with Vermicompost;

Amino acid contents presented in Table 9, showed that cultivar Sakha-1 which was treated with 100 % plant compost attainted the greatest values of therionine, serine, glutamic, valine, hisitidine and proline.

Table 9. Amino acid composition of selected cultivars of faba bean under different treatments (g/100g protein).

Cultivars	Sakha-1			Sakha-4		
Sample/ A.A content	T_5	T_7	T_9	T_5	T_7	T_9
Aspartic(Asp)	8.70	7.95	8.96	7.63	7.35	8.84
Therionine(THR)	3.22	2.77	3.19	2.54	2.63	2.90
Serine(SER)	4.01	3.21	3.79	2.77	3.35	3.19
Glutamic(Glu)	15.55	11.37	15.82	12.33	12.47	13.56
Glycine(GLY)	3.76	3.73	3.87	3.43	2.92	3.73
Alanine(ALA)	4.26	4.87	4.36	4.58	3.32	4.85
Valine(VAL)	4.35	3.86	4.32	3.93	3.57	4.27
Isoleucine(ILE)	3.60	3.47	3.71	2.89	2.60	3.19
Leucine(Leu)	5.90	5.49	6.22	5.05	4.72	5.48
Tyrosine(TyR)	3.43	3.21	3.59	2.66	2.45	2.78
Phenylalanine(PHE)	3.68	3.29	3.71	3.12	2.92	3.28
Hisitidine(HIS)	2.38	2.06	2.42	2.08	1.95	2.32
Lysine(LYS)	5.85	5.00	5.89	5.09	4.69	5.60
Argnine(ARG)	7.32	6.06	7.43	6.40	5.66	6.60
Proline(PRO)	4.43	3.16	4.16	3.16	2.74	3.24
Cysteine(Cys)	1.38	1.80	1.78	1.04	1.12	1.58
Methionine(met)	0.96	1.05	1.05	0.69	0.79	1.00

Where: T_5: 100% plant compost, T_7: 100% chicken manure plus vermicompost and T_9: 100% plant compost plus vermicompost.

However, the same cultivar (Sakha-1) achieved the largest values of aspartic, glycine, isoleucine, leucine, lysine, arginine and methionine under treatment of 50% plant compost plus vermicompost followed by cultivar Sakha-4 which was treated with 50% plant compost plus vermicompost. In agreement with our results, the compost tea and vermicompost tea application recorded a significant increase in protein content in grains of faba bean (Gomaa and Afifi 2021). However, Gad *et al*. (2017) indicated that the compost at a rate of 15 ton/fed with cobalt has a positive effect on minerals composition and chemical constituents of faba bean seeds. Also, organic fertilizers had a positive effect on the chemical constituents (i.e., carotenoids, crude proteins, total free amino acids) of broad bean leaves and seeds either alone or in combination with mineral fertilizers (El-Yazal 2020).

CONCLUSION

The incorporation of plant compost or chicken manure with vermicompost achieved a superior increasing of faba bean yield and seed quality cultivated in sandy soil. Furthermore, our study showed that. Both the two factor (cultivars and treatments of organic fertilizers) were necessary for yield, yield components and quality traits also, showed highly significant mean squares increases for all studied traits. However, the significant positive correlation was found between seed yield per ton and other traits in both years. Remarkably, the interaction between Sakha-1 cultivar and 100 % plant compost plus vermicompost achieved the best combination, which leads to the highest seed yield (3.12 ton/ha), crude protein and amino acid contents.

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الاستجابات الزراعية والغذائية لبعض التراكيب الوراثية من الفول البلدي للتسميد العضوي تحت ظروف الاراضي الرملية

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تعد الاسمدة العضوية ذات المصدر النباتي او الحيواني من المغذيات النباتية الهامة لتحسين أداء أصناف الفول البلدي في مناطق الاستصلاح الزراعية الجديدة. في هذه الدراسة، تم تقييم الصفات الزراعية والقيمة الغذائية لبعض التراكيب الوراثية للفول المصري كاستجابة للتسميد العضوي تحت ظروف التربة الرملية. أجريت تجربتين حقليتين تحت نظام الري بالتنقيط في المحطة التجريبية الصحراوية، كلية الزراعة، جامعة القاهرة – وادي النطرون، محافظة البحيرة، مصر، خلال موسمي شتاء ٢٠١٨/٢٠١٩ و٢٠١٩/٢٠٢٠، تم استخدام تصميم قطع منشقة مرة واحدة في توزيع القطاعات الكاملة العشوائية، بأربعة مكررات وفقًا للعوامل المدروسة، حيث تم تخصيص القطع الرئيسية للأصناف الثلاثة وتخصيص القطع المنشقة لتسعة معاملات (سماد نباتي، مخلفات الدجاج، الفيرموكومبست). أشارت النتائج إلى أن الاصناف ومعاملات السماد العضوي أظهرت معنوية عالية لمتوسط المربعات لجميع الصفات المدروسة. وكذلك ظهر ارتباط موجب ومعنوي بين محصول البذور للهكتار والصفات الأخرى في كلا الموسمين. اظهرت النتائج ايضا استجابة عالية لأصناف الفول إلى السماد النباتي والفيرموكومبست أدت إلى زيادة معنوية في المحصول ومكوناته مقارنة بجميع المعاملات الأخرى. كما ان تطبيق الاضافات والاسمدة العضوية حقق أعلى قيم للمحتويات الكيميائية للبذور. حقق الصنف سخا –١ أعلى استجابة للسماد النباتي بمعدل ١٠٠% معبرة في زيادة المحصول والبروتين الخام ومستخلص الأثير ومحتويات الأحماض الأمينية. التفاعل بين صنف سخا –١ والسماد النباتي بمعدل ١٠٠ % بالإضافة إلى الفيرموكومبست محققاً للتوليفة المثلى، مما أدى إلى أعلى إنتاجية للبذور (٣,١٢ طن / هكتار). ويوصى البحث بهذه التوليفة من أجل تحسين محصول الفول البلدي والجودة الغذائية للبذور تحت ظروف التربة الرملية.

المجلة المصرية لتربية النبات ٢٧(١): ١– ٢٤ (٢٠٢٣)